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# Analysis of Errors Made by Children with Hearing Impairment

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## Abstract

*Making mistakes in mathematics is common and teachers usually ignore the mistake thinking children will overcome it. However, if a pattern of error is observed, it is an indication of some underlying problem in learning mathematics and should be addresses. The present study aims at identifying and addressing the errors made by children with hearing impairment in Arithmetic Diagnostic Test (ADT) for Grade -IV. The errors were analysed qualitatively for mathematical concepts like numeral concept, addition, subtraction, multiplication and division. The errors were classified as in-correct operation, poor concept, non-performers and correct response. The results of analysis revealed that children were able to attempt simple task which had concrete representation (count and write), single digit addition. However, the number of errors increased as the level of difficulty increased. The probable reasons identified for the errors were inability to understand verbal instruction, poor concept of place value, not able to read and follow instruction due to poor reading skill. The common errors identified for addition, subtraction were carrying over and borrowing problem. Multiplication and division were the poorly attempted task and word problems were not attempted or least attempted across all the concepts. The implication of the findings highlights developing a strong number concept among the children, developing their language and reading skills and empowering teachers for error analysis thus paving way for good remedial instruction.*

Keywords: Error analysis, mathematics, language problems.

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## Analysis of Errors Made by Deaf/ Hard of Hearing Children in Mathematics

Mathematics is a subject which requires numerical and language comprehension. Teaching mathematics help students use their mathematical knowledge in solving their daily problems. Mathematical competence is an essential component in preparing numerate citizens for employment and it is needed to ensure the continued production of highly-skilled persons required by industry, science and technology (Mikulski, 2001; Steen, 2001; House 2006). Science and technology is based on mathematics. A society progresses when the citizens are highly skilled and employed. A skillful person is a technologically updated person. According to Steen (2001), mathematics does not only empower people with the capacity to control their lives but also provides science a firm foundation for effective theories and guarantees society a vigorous economy. At its most basic level, mathematics is a requirement for science, computer technology and engineering courses. A good knowledge and understanding of the subject is essential to sustain interest in the subject. Learning mathematics is not easy and if not taught properly, children lose interest in the subject ultimately leading to failure and dropout. According to National Assessment of Educational Progress, 2011, nearly two-thirds of eighth-graders scored below proficient in math. The importance of mathematics, as highlighted above, schools must respond with effective teaching and learning of mathematics from grade one to university level (Department of Education, 2000). Despite the importance of mathematics highlighted , learners continue to fail the subject (Feza-Piyose 2012).

The reasons for failure in mathematics could be attributed to factors like low-performance in mathematics, teacher's lack of understanding of mathematical concepts, teacher's lack of concern over students error and failure to relate to real-life situation. Low performance in mathematics could be due to lack of readiness among the children. If children enter at a disadvantage age, early gaps of understanding between literacy and mathematics is widened or sustained for a longer time. School readiness is not only the meaning of reading and writing but it includes other aspects like cognitive abilities, maturation, social and emotional domains of development (Nobel, Tottenham and Casey, 2005, Ray and Smith, 2010).The non-readiness among the children for learning, impacts their independence and reflective thinking ability. The school readiness in children could be developed with the help of a good teacher. The importance of good teachers is well known. A good student's performance reveals that he has been taught by a good teacher. A teacher's knowledge can influence the learn ability of the students. Goldhaber and Brewer (1996) found that the presence of teachers with

at least a major in their subject area was the most reliable predictor of student achievement scores in math and science. They also found that, although advanced degrees in general were not associated with higher student achievement, an advanced degree specific to the subject area that a teacher taught was associated with higher achievement. Similarly, studies have found that the students taught by certified teachers scored better on the state math achievement test. The same study revealed that the math achievement of elementary students also found that students taught by new, uncertified teachers did significantly worse on achievement tests than did those taught by new, certified teachers (Laczko-Kerr and Berliner 2002). Teachers lack of concern over students error is also a factor for poor performance in mathematics. A qualified teacher in mathematics with good content knowledge, is able to identity errors in mathematics and correct it, thus helping the child with developing a strong mathematical foundation. Teachers of mathematics not only need to calculate correctly, but also know how to use pictures or diagrams to represent mathematics concepts and procedures to students, provide students with explanations for common rules and mathematical procedures, and analyse students' solutions and explanations (Hill, Rowan and Ball). The importance of a knowledgeable teacher could not be ignored keeping in mind the need of the children. Children usually tend to lose interest in any subject when they are not able to relate it to their immediate surrounding and so are with mathematics. Other reasons contributing to low performance in mathematics are poor teaching in the lower grades, the subject is taught by the teacher who themselves don't like it, don't have a deep understanding of it and project something of a fear of it onto their students Thus making mathematics a subject of fear for children thus making considerable errors while learning it. Children tend to make mistakes while learning which should be considered as a process of learning. However, if the same mistake is repeated and a particular pattern is observed in the mistake, then the teacher need to pay attention to the type of mistake made by the child. Errors in mathematics may arise for a variety of reasons. They may be due to the pace of work, the slip of a pen, slight lapse of attention, lack of knowledge or a misunderstanding. Student errors and incorrect responses are the result of students "partial understanding" (Saxe *et al,* 2010) or correct answers to slightly different questions (Wells and Coffey, 2005). Some of these errors could be predicted prior to a lesson and tackled at the planning stage to diffuse or un-pick possible misconception. Saxe *et.al* (2010) continues that instead of considering incorrect responses as errors or mistakes to be avoided, take the position that they are often a normal part of the development of student's understanding of a topic. For developing the student's understanding of the topic, the teacher

needs to have the knowledge of what the misconception might be, why these errors may have occurred and how to unravel the difficulties for the child to continue learning. Teachers can overlook the errors made by children terming it as a regular and random error, addressing these errors and categorising them into a productive mistake is even more challenging. The solution to the problem lies in error analysis, which will help teachers not to ignore mistakes but to categorise into a more productive mistake.

Error analysis is a traditional technique in Mathematical Assessment. It involves the analysis of error patterns to identify difficulties that students may have with facts, concepts, strategies and procedures. Identifying the type of errors, allows the teacher to address learner needs more efficiently. Cox (1975), differentiates between systematic computation errors and errors that are random or careless mistakes. With systematic errors, students are consistent in their use of an incorrect number, operation or algorithm. An analysis of errors helps the teacher to identify the patterns of errors or mistakes that students make in their work, understand why students make the errors and provide targeted instruction to correct the errors. Error analysis helps the teacher to check the students' errors and categorise them. The errors are classified in mathematical areas like addition and subtraction, multiplication and division. Ashlock, (1986), Tindal and Marston (1990) classified students errors into (a) lack of understanding of regrouping, (b) confusion of 1s and 10s in carrying and writing, (c) forgetting to regroup when subtracting 10s and 100s, (d) regrouping when it is not required, (e) incorrect operation and (f) lack of knowledge of basic number facts. Further they have classified errors occurring in multiplication and division into (a) forgetting to carry in multiplication, (b) carrying before multiplying, (c) ignoring place value in division, (d)recording the answer from left to right in multiplication, (e) lack of alignment of work in columns and (f) lack of knowledge of basic number facts. The knowledge of the type of errors made by children will give an insight into the reasons for the errors and measures to overcome the errors.

Researches have made an attempt to compile the type of errors made by the children in mathematics. Usually researchers carry out research involving the development of diagnostic test in order to identify the learning difficulties in some content area or the other and standardising them. These studies, in general, are followed by remedial teaching; there are other studies which only design a remedial teaching approach after administering a suitable standardised test (Rakhi, 2013). Studies on Chinese, Japanese, Korean and Turkish children on the usage of language for teaching mathematics shows that they use simpler words and express math concepts more clearly than English, making it easier for small children

to learn counting and arithmetic. Confusing English word names have been linked in several recent studies to weaker counting and arithmetic skills in children, thus making them prone to errors. (Article published in Wall Street journal).

Asian studies which focused on errors made by children on written mathematical tasks reports that over 50 per cent of the initial errors made were in one of the reading, comprehension and transformation categories related to word problem. It could be concluded that for most errors committed, students had either not been able to understand the word problems or if understanding has been present, they had not devised appropriate strategies for solving the given problems (Ellerton and Clements, 1992).

It could be concluded that studies on mathematical errors comprises of either designing a remedial teaching approach after administering a suitable standardised test or analysing of errors in mathematical word problems. Few studies have made an attempt to give specific insights into the test items and illustrations of student's understanding of any concept or idea. Hence, this forms the need and background for undertaking this study. The study was taken up with the objective of:

1. Administering a standardised mathematics test – Arithmetic Diagnostic Test on children with hearing impairment studying in Grade IV.
2. Analysing the errors (item-wise) on each mathematical concept made by the children in arithmetic diagnostics test.

## Methodology

*Subjects:* A total of 25 students (12 boys and 13 girls) participated in the study. All of them were deaf and hard of hearing (pre-lingually deaf i.e., onset of deafness occurring prior to two years of age). All of them were between the age group of 11 to 13 years. Currently they were the recipients of special education service. All of them had completed Grade IV and were in Grade V at the time of the data collection. All the students were studying maths as a part of their curriculum.

The sample of 25 children was recruited from four special residential schools for the hearing impaired from Mysore (a city in Karnataka, India). All the children who have passed Grade IV and were studying in Grade V were selected for the study, this totaled to 25 children from all the four schools. The criterion for selecting the 25 children is as follows:

## Inclusion Criteria

1. Moderate to profound hearing loss
2. Average intelligence
3. Should be able to communicate orally or through sign language
4. Kannada as the medium of instruction.

   Exclusion Criteria: No other additional disability like learning disability, mental retardation, autism and developmental delay were included.

**Assessment Instruments:** The Assessment instrument for the study was Arithmetic Diagnostic Test (ADT) developed by Ramaa (1994). The test intends to diagnose the specific difficulties encountered by children of Primary Schools, that is Grades I through IV while doing arithmetic sums. The test covers three major areas of arithmetic, namely, Number Concept, Arithmetic Processes (operations)—Addition, Subtraction, Multiplication and Division and Arithmetic Reasoning which is assessed at different levels through word problems and other types of problems dealing with the judicious application of the fundamental arithmetic operations in solving them. Since it is a diagnostic test, it includes sums that represent each type and sun type of tasks that fall under each of the aforementioned three major areas. Thus the test is quite comprehensive in identifying the strength and weaknesses of the children. The test is developed in such a way that the items are appropriate to different grades of the primary school stage, cumulative and varies from each other at the minimal difference level. Each subtype of the task is represented by two items in the case of arithmetic processing and reasoning. This helps in thorough diagnosis of the difficulties faced by the children in dealing with particular subtype of arithmetic task. The sub-items and the items are arranged in the order of increasing difficulty level within the different sections of sums as well as between the sections. The test was available in English and Kannada. The Kannada version was used for the study due to its relevance with the medium of instruction of the student. Prior permission was sought from the author of the test to use the test material for the purpose of the research.

## Collection of Data

The data was collected by administering the test in the school where the

**Table 1**
**The Technique of Collecting the Information is Given in**

| Sl. No. | Inclusion Criteria for Selecting the Children | Technique of selecting the children |
|---|---|---|
| 1 | Moderate to profound hearing loss | Audiological evaluation report from the school |
| 2 | Average intelligence | Standard progressive matrices : (Raven , 1983) |
| 3 | Should be able to communicate orally or through sign language | Observation and informal conversation |
| 4 | Kannada as the medium of instruction | - |

students were studying. Permission was sought from the principals of the school for carrying the test. The participants were made to sit separately. Each one of the participant got individual test material. Clear instruction as to 'how to solve the questions' was given at the beginning of the test. The data was collected by administering the test in two separate sessions of 45 minutes each to avoid fatigue factor. The students used total communication as the mode of communication. Most of them were poor with their reading skills and hence the researcher had to explain with the help of spoken language or gestures and give one example for them to understand the test.

## Method of analysis of data

The performance of the children (25 nos.) on Arithmetic Diagnostic Test-Grade IV was assessed qualitatively which aimed identifying and classifying the types of error made by the children. The types of errors were classified as 1) Incorrect operation wherein the children performs a wrong operation, skips a step, does not follow verbal instruction. 2) poor concept: the skill for a particular concept is not developed like addition of fractions, mixed operations and division. 3) Non-performers: the children does not perform a single task and does not attempt it. 4). Correct Response: the child has performed the task with skipping any steps.5) Careless/Random Errors: The concept is developed, but the child does simple errors, but repetition of a particular pattern is not seen. The total number of children was converted into percentages for the purpose of analysis. The results are depicted in tables 2,3,4,5,6 and the reason for deficiency is discussed below.

## Result and Discussion

The errors in writing words for numbers were found in children. As the complexity of the task increased, they did not attempt the activity. They committed spelling errors and number errors. The children found difficulty

**Table 2**
**Type of Error and Percentage of Children Committing Error in Number Concept**

| Sl. No. | Instructional Objectives (What the student is expected to do) | Nature of problem Encountered | Error/deficiency | % of children committing the error |
|---|---|---|---|---|
| 1 | Count and Write | Random / careless errors | | 8 |
| 2 | Writing words for numbers | Non-performers | Not attempted as the complexity of the task increases. | 92 |

| | | | | |
|---|---|---|---|---|
| 3 | Writing numbers for words | Poor concept | Difficulty in identification and writing when the numbers exceed two digits | 80 |
| 4 | Writing numbers in correct sequence | Poor Concept and Non-performers | Difficulty in writing numbers in sequence when the numbers exceed two digits | 36 |
| 5 | Lesser than and greater than | Poor Concept and Non-performers | Poor understanding or difficulty in following the written or spoken information | 60 |
| 6 | Writing numbers in an increasing order | Poor Concept and Non-performers | Poor understanding or difficulty in following the written or spoken information | 52 |

**Table 3**
**Type of Error and Percentage of Children Committing Error in Addition**

| Sl. No. | Instructional Objectives (what the student is expected to do) | Nature of problem Encountered | Error/ deficiency | % of children committing the error |
|---|---|---|---|---|
| 1 | Add the numerals (vertically) | Incorrect operation/adding (Skip a step or number and difficulty in carrying over and adding extra digit) | Forgets to add the carried digits to the next place value | 64 |
| | | Poor concept | Poor understanding of the addition concept. | 16 |
| | | Careless errors/Random errors | | 12 |
| | | Correct response | | 8 |

| | | | | |
|---|---|---|---|---|
| 2 | Add the numerals (horizontally) | Poor Concept (addition of fractions) and Random Errors | Not learnt procedure of adding fractions or avoiding difficult task. | 100 |
| | | | | |
| 3 | Writing digits in an increasing order | Poor concept (lack of understanding of instruction) | Poor understanding or difficulty in following the written or spoken information | 92 |
| | | Incorrect operation (wrong procedure) | | 8 |
| 4 | Solving addition word problems | Incorrect operation (difficulty in reading and comprehending word problems) | Difficulty in processing verbal numerical information | 92 |
| | | Non-performers | | 8 |

in following the instruction written in words. Thus many of them did not attempt activities where they had to read and follow instructions. The wordiness of mathematical problems creates difficulties for hearing students as well as those with hearing loss. The linguistic aspects of mathematics create difficulties for them (Wood, Wood, Griffith and Howarth 1986).

Forgetting to add the carried number, and difficulty in adding fractions were the problems encountered by the children in the addition concept. The error committed could be due to the working memory. Mathematical competence requires a variety of skills that encompasses different conceptual content and procedures wherein partial information is held back and new information is processed to arrive at a solution. This requires working memory (Bisanz, Sherman, Rasmussen, and Ho, 2005). Children having problems with working memory also face problem with processing information and sentence comprehension. The concept of addition was known to them however, the error occurred when carrying over the digit.

Subtraction activity involving borrowing requires the understanding of place value and a good processing memory. The above table clearly shows that simple single digit subtraction sums were attempted by the children; however, error was identified in subtraction sums involving borrowing digits from the higher place. The errors

**Table 4**
**Type of Error and Percentage of Children Committing Error in Subtraction**

| Sl. No. | Instructional Objectives (what the student is expected to do) | Nature of problem Encountered | Error / Deficiency | % of children committing the error |
|---|---|---|---|---|
| 1 | Subtract the numerals (vertically) | Random Errors | | 16 |
| | | Incorrect operation (no borrowing/ inappropriate borrowing) | Forgets to borrow number from the next place value or incorrect borrowing. | 52 |
| | | Non-performers | Poor understanding of the subtraction concept. | 24 |
| | | Correct response | | 8 |
| 2 | Subtract the numerals (horizontally) | Incorrect Operation | Difficulty in subtractions involving fractions and number exceeding two digits | 72 |
| | | Non-performers | | 28 |
| 3 | Writing digits in decreasing order | Poor Concept | Poor understanding or difficulty in following the written or spoken information | 28 |
| | | Non-performers | | 72 |
| 4 | Solve the following problems (mixed operations) | Incorrect Operation | Not learnt the procedure of doing mixed operation sums | 44 |
| | | Non-performers | | 56 |
| 5 | Indicate whether the statement is true or false (mixed operation) | Poor Concept | Poor understanding of mixed operation or not able follow written or oral instructions | 8 |
| | | Non-performers | | 52 |
| | | Correct Response | | 40 |

| | | | | |
|---|---|---|---|---|
| 6 | Solve the following word problems | Incorrect Operation | Difficulty in processing verbal numerical information | 40 |
| | | Non-performers | | 60 |
| | | Correct Response | | |
| 7 | Solve the following problems (The child is expected to fill in the missing numbers by performing the subtraction) | Poor Concept (lack of understanding of instruction) | Not learnt the procedure | 8 |
| | | Random Errors | | 32 |
| | | Non–performers | | 60 |

could be due to poor working memory. Studies have shown that working memory is important for many aspects of mathematical performance, including use of complex arithmetic procedures that involve carrying and borrowing operations (Ashcraft, 1992; De Rammelaere, Stuyven and Vandierendonck, 1999, 2001; Frensch and Geary, 1993; Geary, Frensch and Wiley, 1993; Hecht, 2002;

The above table clearly shows that performing multiplication related task was difficult as many children did not attempt them. However, among those children who attempted the task had

**Table 5**
**Type of Error and Percentage of Children Committing Errors in Multiplication**

| Sl. No. | Instructional Objectives (what the student is expected to do) | Nature of problem Encountered | Errors/ deficiency | % of children committing the error |
|---|---|---|---|---|
| 1 | Multiplying the numbers (arranged horizontally) | Incorrect operation (difficulty with multiplying three digit numbers to another three digit numbers or multiple numbers) | Did not learn the skill of multiplying three digit numbers to another three digit numbers or more | 20 |
| | | Random Errors | | 36 |
| | | Poor Concept | Does not know multiplication | 20 |
| | | Non-performers | | 24 |

| | | | | |
|---|---|---|---|---|
| 2 | Write the following in an increasing order based on their products | Incorrect operation | Poor understanding of the multiplication skill or difficulty in following the written or spoken information | 32 |
| | | Non-performers | | 68 |
| | | | | |
| 3 | Solve the following problem (mixed operation) | Poor Concept | Not learnt the skill of doing multiplication involving mixed operation | 32 |
| | | Non-performers | | 64 |
| | | Correct response | | 4 |
| 4 | Solve the following word problems | Incorrect Operation | Not able to process verbal numerical information | 8 |
| | | Non-performers | | 92 |
| 5 | Indicate whether the statement is true or false | Incorrect operation | Poor understanding of the multiplication skill or difficulty in following the written or spoken information | |
| | | Non-performers | | 88 |
| | | Correct response | | 12 |

also done it incompletely resulting in errors like carrying out addition in place of multiplication, wrong tables and omitting sums having more than three digits. It could also be observed that 92 per cent of children did not attempt word problems or tasks which required them to read and follow instructions. This means that, for most errors, students had either not been able to understand the word problems or, if understanding had been present, they had not devised appropriate strategies for solving the given problems. Clements and Ellerton (1992), reports that language is an important factor in the development of mathematical concepts. A frequent observation in educational settings is that children with profound hearing impairments as well as deaf children quite often experience difficulties to acquire calculation skills (Zarfaty et al., 2004; Ansell and Pagliaro, 2006).

The error in division shows that children did not learn the skill of dividing, as many children did not attempt the tasks. The task which they had attempted was classified under poor concept as they did multiplication instead of division, they did not attempt task involving mixed operations and avoided tasks involving word problems and verbal instruction, which was difficult for them to comprehend. For children to succeed in mathematics, a number of brain functions need to work together. Children must be able to use memory to recall rules and formulas and recognise patterns; use language to understand vocabulary, instructions,

**Table 6**
**Type of Error and Percentage of Children Committing Errors in Division**

| Sl. No. | Instructional Objectives (what the student is expected to do) | Nature of problem Encountered | Errors/ Deficiency | % of children committing the error |
|---|---|---|---|---|
| 1 | Divide the following (children are expected to divide horizontally) | Poor Concept | Does not know division | |
| | | | | 4 |
| | | Non-performers | | 84 |
| | | Correct response | | 12 |
| 2 | Divide the following vertically | Incorrect Operation | Does not know division, doing multiplication instead of divisiopn | 8 |
| | | Non-performers | Does not know division when more than one step is involved. | 68 |
| | | Random Errors | | 16 |
| | | Correct response | | 8 |
| 3 | Solve the following problems (mixed operation) | Incorrect operation | Not learnt the skill of doing division involving mixed operation | 12 |
| | | Non-performers | | 88 |
| 4 | Solve the following word problem | Non-performers | Did not attempt as not able to process verbal information | 76 |
| | | Poor concept | | 24 |

and explain their thinking; and use sequential ordering to solve multi-step problems and use procedures. Higher-order cognition helps children to review alternative strategies while solving problems, to monitor their thinking, to assess the reasonableness of their answers, and to transfer and apply learned skills to new problems. Often, several of these brain functions need to operate simultaneously (Nathan, Lauren and Nathan, 2002). This is usually difficult with children with hearing impairment and hence they face difficulty with mathematical operation.

The other area to be focused is the pattern of errors attempted by children in word-problem. Most of the children did not attempt the task or performed it incorrectly (did addition in place of subtraction,

copied the same statement without comprehending) due to the wordiness in the verbal language of the word problems. The effect of language on mathematics performance for disadvantaged students (here children with hearing impairment) has been noted (Zevenbergen, 2000), and this suggest that difficulty is similar to hearing peers. This difficulty in understanding may be due to the development of alternative language; sign language (Frostad, 1999) that impacts on the types of understandings that students develop with regard to mathematical concepts.

## Conclusion

Children making mistakes in mathematics is common, however, when the pattern of error is identified, an extra attention need to be paid to the performance of the children. The error analysis clearly revealed that simple number task which had concrete representation like count and write was attempted by all the children except two making random errors, but tasks like writing number names for the given numerals was not performed by 92 per cent of the children. Similarly task involving reading verbal instruction and following was also skipped by most of the children with hearing impairment. One of the important challenges in mathematics teaching is to help students make connections between the mathematics concepts and the activity. Children may not automatically make connections between the work they do with manipulative materials and the corresponding abstract mathematics. Children tend to think that the manipulations they do with models are one method for finding a solution and pencil-and-paper math is entirely separate (Burns and Silbey, 2000, p. 60). This is true with children with hearing impairment. Due to language deficiency, children fail to understand the abstract concept like place value, which forms the foundation over which other concepts like addition, subtraction, multiplication and division is developed. Poorly developed place value concept had an effect on other concepts like addition where the children did not carry over the number to the next place value or in subtraction where they did incorrect borrowing. It was also observed that these children lack logical thinking. Because, they carried out incomplete multiplication sums. Children learn concept in such a way that they develop the ability to think mathematically thus refining their existing knowledge and construct new ideas (Haynes, 1999)

The importance of language cannot be ignored and it is clearly observed in the study, wherein the children are skipping word related problems. Pau (1995) states that in order to solve written problems correctly deaf/hearing impaired children need to correctly interpret every one of the words contained in the problem's text. In terms of verbal problems, deaf/hearing impaired children make an attempt to simplify the problems by converting them into understandable linguistic

forms. He suggests that "It is therefore vital that any teaching programme designed to improve the child's problem-solving level should include general text-comprehension and, in particular, mathematics text-comprehension activities". Additionally, the teachers' role in teaching mathematics cannot be ignored. However, it is observed that, teachers tend to pay less attention in evaluating the children and identifying the errors. The reason for this could be the fact that the impairment in the child prevents him/her from attempting the mathematical task. The teacher neglects the errors made by them thinking that it is a predisposition of the child leaving it unattended. This research also implies the needs of an effective remedial programme and establishing a base for developing an Individualised Education Programme for addressing the mathematical problems of the children.

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